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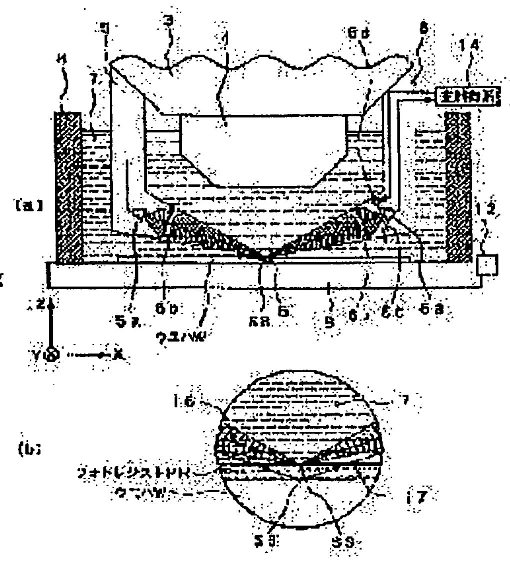
(71)Applicant : NIKON CORP
(72)Inventor : SHIRAISHI NAOMASA

(54) PROJECTION ALIGNER

(57)Abstract:
PROBLEM TO BE SOLVED: To detect with high precision a position in an optical axis direction of a projection optical system on a surface of a substrate, even when wavelengths of aligned lights are substantially reduced and moreover the alignment is carried out in a liquid.
SOLUTION: A liquid 7 is supplied to a sidewall 8 so as to satisfy a gap between a lens 4 of a projection optical system which is closest to a wafer W and the wafer W. Ultrasonic waves are emitted from an ultrasonic emission system 5, and the ultrasonic waves reflected by an ultrasonic focusing position SS are received by an ultrasonic reception system 6. Based on a detection signal from the ultrasonic reception system 6, a defocusing amount from a best focusing position in a focusing position SS of ultrasonic waves is acquired. Based on the acquired defocusing amount, a sample ore pedestal 9 is driven in a Z-direction to control a focusing position.



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CLAIMS

[Claim(s)]

[Claim 1] The projection aligner characterized by to have field location detection equipment of the ultrasonic sensing method which detects the location of the direction of an optical axis of said projection optics of said front face by detecting the supersonic wave which sends out a supersonic wave to the immersion equipment which supplies a predetermined liquid to the front face of said substrate, and the front face of said substrate through said liquid in the projection aligner which imprints a mask pattern on a substrate through projection optics, and is reflected on said front face.

[Claim 2] It is the projection aligner according to claim 1 characterized by said field location detection equipment detecting the location of the direction of an optical axis of said projection optics of the front face of said sensitive material when sensitive material is applied to the front face of said substrate.

[Claim 3] Claim 1 characterized by supplying said liquid so that between the point of the optical element by the side of said substrate of said projection optics and the front faces of said substrate may be filled, or a projection aligner given in two.

[Claim 4] Said liquid is a projection aligner claims 1 and 2 characterized by being water or an organic solvent, or given in three.

[Claim 5] The projection aligner of claim 1-4 characterized by having the substrate stage which holds said substrate and positions this substrate on a flat surface perpendicular to the optical axis of said projection optics, and the height control stage which controls the location of the direction of an optical axis of said projection optics of said substrate based on the detection result of said field location detection equipment given in any 1 term.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the projection aligner used for the lithography process for manufacturing a semiconductor device, a liquid crystal display component, or the thin film magnetic head.
[0002]
[Description of the Prior Art] In case a semiconductor device etc. is manufactured, projection aligners, such as a stepper mold imprinted to each shot field on the wafers (or glass plate etc.) with which the image of the pattern of the reticle as a photo mask was applied to the resist as a substrate through projection optics or step -, and - scanning method, are used.

[0003] The resolution of the projection optics with which the projection aligner is equipped becomes so high that the exposure wavelength to be used is short and the numerical aperture of projection optics is large. Therefore, exposure wavelength used with a projection aligner with detailed-izing of an integrated circuit is short-wavelength-ized every year, and the numerical aperture of projection optics has also been increasing. And although the exposure wavelength of the current mainstream is 248nm of KrF excimer laser, 193nm use of the ArF excimer laser of short wavelength is also considered further.
[0004] Moreover, in case it exposes, the depth of focus as well as resolution becomes important. Resolution R and the depth of focus delta are expressed with the following formulas, respectively.
R=k1 and lambda/NA (1)
Delta=k 2 and lambda/NA 2 (2)
Here, lambda is exposure wavelength and NA is the numerical aperture of projection optics, k1, and k2. It is a process multiplier. When obtaining the same resolution, the depth of focus with bigger using the exposure light of short wavelength can be obtained. however, the spectrum of the penetrable optical member (** material) used for projection optics — if a transparency property is taken into consideration, while being able to penetrate the exposure light of the wavelength of ArF excimer laser shorter than 193nm at present, there is almost no uniform ** material which can form a comparatively big lens.
[0005]
[Problem(s) to be Solved by the Invention] It is difficult like the above to use the exposure light of the wavelength of ArF excimer laser shorter than 193nm in the conventional projection aligner (projection optics). Then, it considers as the approach of shortening exposure wavelength substantially, and the immersion method is proposed. A wafer is dipped into a predetermined liquid, and this improves resolution using the wavelength of the exposure light in the inside of a liquid increasing 1/n time in air (n being usually 1.2 to about 1.6 at the refractive index of a liquid), and increases the depth of focus.
[0006] By the way, since the whole exposure range needs to enter within the limits of the depth of focus of projection optics at the time of exposure, the focus device (automatic focus device) is prepared in the projection aligner. Incidence of the light beam is carried out to the front face of the wafer which should generally be exposed by oblique incidence, the reflected light is received by the optical system of a confrontation, the focus condition on the front face of a wafer is detected, and this moves a wafer up and down, and drives in to a focus location.
[0007] The film (photoresist) is applied to the wafer front face exposed, and a pattern is imprinted by this photoresist. Then, it is desirable to make this photoresist front face in agreement with the focal location of projection optics, and it needs to detect ****** on the front face of a photoresist. The space where a wafer is arranged is filled with the conventional projection aligner with gases, such as air or nitrogen. And the refractive index of air is 1, for example, and the refractive index of the photoresist applied to the wafer front face is about 1.7. Therefore, the reflection factor of the light in an air-photoresist interface is calculated as follows than Fresnel's formulas.
Reflection factor = [(1-1.7) /(1+1.7)] 2x100 = 6.7 (%) (3)
an air-photoresist interface -- the flux of light for focus detection -- many reflect comparatively and the location on the front face of a photoresist can be detected.
[0008] However, the space where a wafer is arranged will be filled with a liquid at the case of the projection aligner which adopted the immersion method. For example, when a liquid is water, the refractive index is 1.3 and the reflection factor of the light in a water-photoresist interface is calculated as follows than Fresnel's formulas.
Reflection factor = [(1.3-1.7) /(1.3+1.7)] 2x100 = 1.8 (%) (4)
In a water-photoresist interface, since the difference of the refractive index of space and a photoresist becomes remarkably small compared with an air-photoresist interface, the reflection factor of the flux of light for focus detection falls, and it becomes difficult to detect the location on the front face of a photoresist correctly.
[0009] This invention short-wavelength-izes wavelength of exposure light in view of this point, and it aims at offering the projection aligner which can imprint a more detailed pattern. Furthermore, even if it is the case where exposure is performed on the substrate with which sensitive material was applied in the liquid, it aims also at offering the projection aligner which can detect the location of the direction of an optical axis of the projection optics of the front face of the sensitive material with high precision.
[0010]

[Means for Solving the Problem] In the projection aligner with which the projection aligner of this invention imprints the pattern image of a mask (R) on a substrate (W) through projection optics (PL) The immersion equipment which supplies a predetermined liquid (7) to the front face of the substrate (W) (2 8), A supersonic wave is sent out to the front face of the substrate (W) through a liquid (7), and it has field location detection equipment (5 6) of the ultrasonic sensing method which detects the location of the direction of an optical axis of the projection optics (PL) of the front face by detecting the supersonic wave reflected on the front face.
[0011] According to the projection aligner of this this invention, since the pattern image of a mask (R) is exposed on the surface of a substrate (W) through a liquid (7),-izing of the wavelength of the exposure light in a substrate front face can be carried out [short wavelength] 1/n time (n is the refractive index of a liquid (7)) of the wavelength in air. Moreover, since the field location detection equipment (5 6) of an ultrasonic sensing method detects the location of the direction of an optical axis of the front face of a substrate (W) with high precision, with optical field location detection equipment, detection of a field location can detect the location with high precision in a difficult liquid (7).
[0012] Moreover, when sensitive material (PR) is applied on the surface of the substrate (W), as for field location detection equipment (5 6), it is desirable to detect the location of the direction of an optical axis of the projection optics (3 4) of the front face of the sensitive material (PR). In this case, the image surface of projection optics (3 4) can be doubled with the front face of that sensitive material (PR). Moreover, it is desirable to supply a liquid (7) so that between the points and the front faces of a substrate (W) of the optical element (4) by the side of the substrate (W) of projection optics (PL) may be filled. In this case,-izing of the wavelength of the exposure light in a substrate (W) front face can be carried out [short wavelength] 1/n time (n is the refractive index of a liquid (7)) of the wavelength of the exposure light in air. Furthermore, in order that the lens-barrel (3) of projection optics (PL) may not contact a liquid (7), there is an advantage of being hard coming to corrode a lens-barrel (3).
[0013] Moreover, the liquid (7) is water (refractive index 1.3) or organic solvents (for example, alcohol (ethanol (refractive index 1.36) etc.), cedar oil (refractive index 1.52), etc.). In this case, in using water as a liquid (7), there is an advantage that that acquisition is easy. Moreover, in using an organic solvent as a liquid (7), there is an advantage of being hard coming to corrode the lens-barrel (3) of projection optics (PL). Furthermore, when using cedar oil as a liquid (7), the refractive index is as large as about 1.5, and can short-wavelength-ize exposure light more.
[0014] Moreover, it is desirable to have the substrate stage (10) which holds a substrate (W) and positions this substrate (W) on a flat surface perpendicular to the optical axis of projection optics (PL), and the height control stage (9) which controls the location of the direction of an optical axis (3 4) of the projection optics of that substrate (W) based on the detection result of field location detection equipment (5 6). In this case, the front face of a substrate (W) can be doubled with high precision to the image surface of projection optics (3 4).
[0015]
[Embodiment of the Invention] Hereafter, with reference to drawing 1 - drawing 3 , it explains per example of the gestalt of operation of this invention. Drawing 1 (a) shows the outline configuration of the projection aligner of this example, and the exposure light IL which consists of ultraviolet pulsed light with a wavelength of 193nm injected from the illumination-light study system 1 containing the ArF excimer laser as the exposure light source, an optical integrator, a field diaphragm, a condensing lens, etc. illuminates the pattern prepared in Reticle R in this drawing 1 (a). the pattern of Reticle R -- a both-sides (or wafer side one side) tele cent -- contraction projection is carried out to the exposure field on the wafer W with which Photoresist PR was applied through the rucksack projection optics PL for the predetermined projection scale factor beta (beta is 1/4, and 1 / 5 grades). In addition, as an exposure light IL, KrF excimer laser light (wavelength of 248nm), F2 excimer-laser light (wavelength of 157nm), i line (wavelength of 365nm) of a mercury lamp, etc. may be used. The Z-axis is taken in parallel with the optical axis AX of projection optics PL hereafter, a Y-axis is taken along a direction perpendicular to the space of drawing 1 (a) in a flat surface perpendicular to the Z-axis, and the X-axis is taken and explained along a direction parallel to space.
[0016] Reticle R is held on a reticle stage RST, and the device which can be moved slightly to the direction of X, the direction of Y, and a hand of cut is included in the reticle stage RST. The two-dimensional location of a reticle stage RST and the angle of rotation are measured by real time with the laser interferometer (un-illustrating). On the other hand, Wafer W is held on the sample base 9 through a wafer holder (un-illustrating), and the sample base 9 is being fixed on Z stage 10 which controls the focal location (location of a Z direction) and tilt angle of Wafer W. On the sample base 9, the cylinder-like side attachment wall 8 is established, and gets down, and the interior is filled with the liquid 7. A liquid 7 is supplied in a side attachment wall 8 before exposure through nozzle 2a by the liquid supply recovery system 2 which consists of a pump etc., and are collected after exposure. In addition, in the projection aligner of this example, since water (refractive index 1.3) is used as a liquid 7 and the wavelength of light increases 1/1.3 time in air in underwater, wavelength of exposure light which consists of ArF excimer laser (wavelength of 193nm) is substantially short-wavelength-ized by about 148nm.
[0017] Moreover, the lens-barrel 3 of projection optics PL is metal, and it is using the contact part of projection optics PL and a liquid 7 only as the lens 4 nearest to Wafer W in this example in order to prevent corrosion with a liquid 7. Moreover, the focal location detection system (it is called "the AF sensors 5 and 6" below) which consists of an ultrasonic injection system 5 and an ultrasonic receiving system 6 is attached in the side face of the lens-barrel 3 of projection optics PL.
[0018] Drawing 1 (b) is an about eight side attachment wall [of drawing 1 (a)] enlarged drawing, and door 8a which can be opened and closed and which is used in the case of taking out from conveyance of a up to [the sample base 9 of Wafer W] or the sample base 9 is prepared in the side attachment wall 8 in this drawing 1 (b). Moreover, nozzle 2a of the liquid supply recovery system 2 has supply of a liquid, and composition which can be driven up and down in the case of recovery.
[0019] Return and Z stage 10 are fixed by drawing 1 (a) on X-Y stage 11 which moves along XY flat surface parallel to the image surface of projection optics PL, and X-Y stage 11 is laid on the non-illustrated base. Z stage 10 controls the focal location (location of a Z direction) of Wafer W, and a tilt angle, and doubles the photoresist PR front face on Wafer W with the image surface of projection optics PL by the automatic focus method and the auto leveling method, and X-Y stage 11 performs alignment of the direction of X of Wafer W, and the direction of Y. The two-dimensional location of the sample base 9 (wafer W) and the angle of rotation are measured by real time with the laser interferometer 13 as a

location of the migration mirror 12. Based on this measurement result, control information is sent to the wafer stage drive system 15 from the main control system 14, actuation of Z stage 10 and X-Y stage 11 is controlled, each shot field on Wafer W moves to a sequential exposure location at the time of exposure, and the exposure imprint of the pattern of Reticle R is carried out to each shot field.

[0020] Next, the AF sensors 5 and 6 of the projection aligner of this example are explained. Drawing 2 (a) expands and shows near the lower part of the projection optics of this example, and ultrasonic generating component 5a and focussing-of-ultrasonic-waves component 5b are prepared in the ultrasonic injection system 5 in this drawing 2 (a). It converges on the focusing location SS on the photoresist PR front face applied to Wafer W by focussing-of-ultrasonic-waves component 5b, it reflects in the focusing location SS, and incidence of the supersonic wave with a frequency of 50MHz - about 200MHz injected from ultrasonic generating component 5a which consists of a piezoelectric device etc. is carried out to the ultrasonic receiving system 6. Ultrasonic receiving component 6a, focussing-of-ultrasonic-waves component 6b, and noise insulation plate 6c that can vibrate are prepared in the ultrasonic receiving system 6, and the supersonic wave which carried out incidence to the ultrasonic receiving system 6 converges by focussing-of-ultrasonic-waves component 6b, and carries out incidence to ultrasonic receiving component 6a through opening of noise insulation plate 6c. The detecting signal of ultrasonic receiving component 6a is supplied to the main control system 14. In addition, opening which passes a supersonic wave is prepared in the center section of noise insulation plate 6c, and the location where the main control system 14 carries out the horizontal shift (or vibration) of the noise insulation plate 6c by 6d of noise insulation plate drives, and the detecting signal of ultrasonic receiving component 6a becomes max is detected. Or the synchronous detection of the detecting signal of ultrasonic receiving component 6a may be carried out by the signal which synchronized with vibrating noise insulation plate 6c.

[0021] Drawing 2 (b) expands and shows near focusing location SS of the supersonic wave on a photoresist PR front face, and the photoresist PR for sensitization is applied on Wafer W in this drawing 2 (b). In order that AF sensor of an oblique incidence method detects the location SS on a photoresist PR front face by optical [conventional], the refractive index of the liquid 7 and Photoresist PR also as a way may be comparable, a reflection factor may become very low and light may go to the front face of Wafer W in accordance with a path 17, location SS' detected is not located on the front face of Photoresist PR, but is doubled with the image surface of projection optics PL in the front face of the substrate of Wafer W itself. Since it progresses in accordance with a path 16 and is reflected on the front face of Photoresist PR, the location SS on a photoresist PR front face is detected correctly, and the supersonic wave of the AF sensors 5 and 6 of this example can make a photoresist PR front face focus to the image surface with high precision.

[0022] Moreover, the location of the Z direction of a photoresist PR front face is detected by optical [conventional] by the same principle as AF sensor of an oblique incidence method from the horizontal shift amount of the focusing location of the supersonic wave on ultrasonic receiving component 6a. That is, if the focusing location on ultrasonic receiving component 6a of drawing 2 (a) will shift up if Wafer W shifts down [in drawing 2 (b)] (- Z direction), and Wafer W shifts above [in drawing 2 (b)], since the focusing location on ultrasonic receiving component 6a shifts caudad, it can calculate the variation of the focal location of the front face of Photoresist PR from this horizontal shift amount. Therefore, beforehand, the best focus location is defined with the test print etc., and should just double the core (or oscillating core) of opening of noise insulation plate 6c, and the core of the focusing location of a supersonic wave then.

[0023] Drawing 3 shows relation with the focal location Z of the focal signal D and a photoresist PR front face obtained by carrying out the synchronous detection of the detecting signal from the ultrasonic receiving system 6 as an example. Within the main control system 14, the focal signal D which changes in proportion [almost] to the focal location Z in the predetermined range is generated corresponding to the focusing location SS of the supersonic wave in a photoresist PR front face by detecting synchronously the detecting signal from ultrasonic receiving set 6a with the driving signal of noise insulation plate 6c. In this example, when the focusing location SS has agreed in the image surface (best focus location) of projection optics PL, the calibration is performed so that it may be set to 0, and as for the main control system 14, the focal signal D corresponding to the focusing location SS of a supersonic wave can calculate the amount of defocusing (the amount of gaps) from the focal signal D. When the focal location of Wafer W is up, Z stage 10 (wafer W) is moved caudad, and when there is a focal location caudad conversely, it will expose by moving Z stage 10 (wafer W) up.

[0024] In addition, although water (refractive index 1.3) was used as a liquid 7 in this example, organic solvents (for example, alcohol, cedar oil, etc.) can also be used as a liquid 7. In this case, there is an advantage of being hard coming to corrode the lens-barrel 3 of projection optics PL. Moreover, when using cedar oil (refractive index 1.5), the refractive index is as large as 1.5, and can short-wavelength-ize exposure light more substantially.

[0025] In addition, the noise insulation plate which has two or more openings in the ultrasonic injection system 5 about detection of a focal location is arranged. You may make it detect each focal location of the two or more on the front face of a photoresist. Or the noise insulation plate which arranges the noise insulation plate which has big opening in the ultrasonic injection system 5, and has two or more openings is arranged in the ultrasonic receiving system 6, and you may make it detect each focal location in two or more points similarly.

[0026] In addition, with the gestalt of the above-mentioned operation, although the focal location on the front face of a photoresist of a wafer was detected using the supersonic wave, the leveling sensor which detects the tilt angle on the front face of a photoresist using a supersonic wave may be used. What is necessary is to irradiate the supersonic wave which progresses almost in parallel on the surface of a wafer, and just to detect the sound-collecting location of the supersonic wave reflected by this leveling sensor.

[0027] In addition, of course, configurations various in the range which this invention is not limited to the gestalt of above-mentioned operation, and does not deviate from the summary of this invention can be taken.

[0028]

[Effect of the Invention] According to the projection aligner of this invention, since the pattern image of a mask is exposed on the surface of a substrate through a liquid,-izing of the wavelength of the exposure light in a substrate front face can be substantially made [short wavelength] twice [inverse number] the refractive index of the liquid of the wavelength in air. Moreover, since the field location detection equipment of an ultrasonic sensing method detects the location of the direction of an optical axis on the front face of a substrate, with optical field location detection equipment, detection of a field location can detect the location with high precision in a difficult liquid.

[0029] Moreover, when field location detection equipment detects the location of the direction of an optical axis of the

projection optics of the front face of sensitive material, based on the detection information, the front face of the sensitive material can be doubled with high precision to the image surface of projection optics. Moreover, when a liquid is supplied so that between the points and the front faces of a substrate of the optical element by the side of the substrate of projection optics may be filled,-izing of the exposure light can be carried out [short wavelength] 1/n time in air (n is the refractive index of a liquid), and in order that the lens-barrel of projection optics may not contact a liquid, there is an advantage of being hard coming to corrode the lens-barrel of projection optics.
[0030] Moreover, when a liquid is water, there is an advantage that the acquisition is easy. When liquids are organic solvents (for example, alcohol, cedar oil, etc.), there is an advantage of being hard to corrode the lens-barrel of projection optics. Furthermore, when using cedar oil as a liquid, the refractive index is large compared with 1.5, water (refractive index 1.3), etc., and exposure light can be short-wavelength-ized more.
[0031] Moreover, when it has the substrate stage which holds a substrate and positions this substrate on a flat surface perpendicular to the optical axis of projection optics, and the height control stage which controls the location of the direction of an optical axis of the projection optics of that substrate based on the detection result of field location detection equipment, the image surface of projection optics can be doubled with the exposure location on a substrate front face.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The outline block diagram in which (a) shows the projection aligner of an example of the gestalt of operation of this invention, and (b) are the enlarged drawings showing about eight side attachment wall of drawing 1 (a).
[Drawing 2] The partial enlarged drawing in which (a) shows the configuration of the projection aligner lower part of drawing 1 (a), and (b) are the enlarged drawings of the B section of drawing 2 (a).
[Drawing 3] It is drawing showing the focal location Z on the front face of a photoresist on Wafer W, and relation with the focal signal D.
[Description of Notations]
W Wafer
R Reticle
PL Projection optics
1 Illumination-Light Study System
2 Liquid Supply Recovery System
3 Lens-barrel
4 Lens
5 Ultrasonic Injection System
6 Ultrasonic Receiving System
7 Liquid
8 Side Attachment Wall
9 Sample Base
10 Z Stage
14 Main Control System
15 Wafer Stage Drive System

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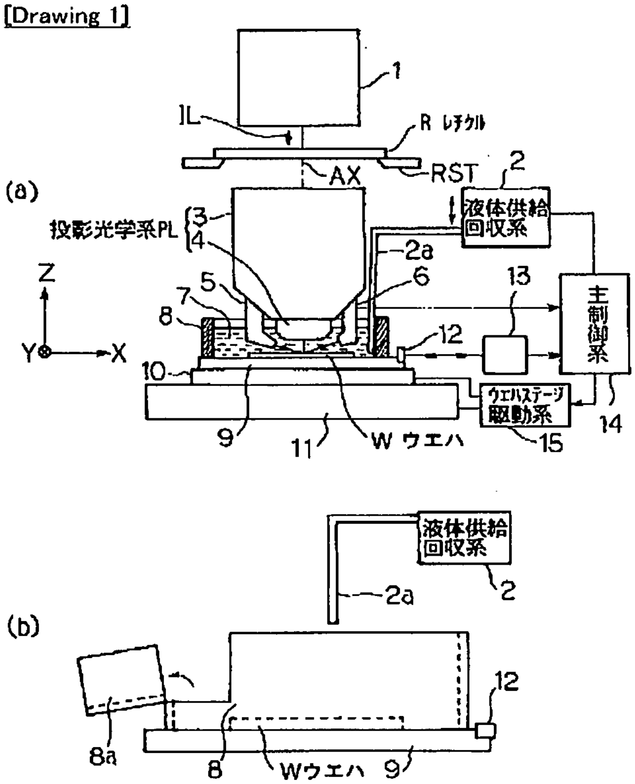
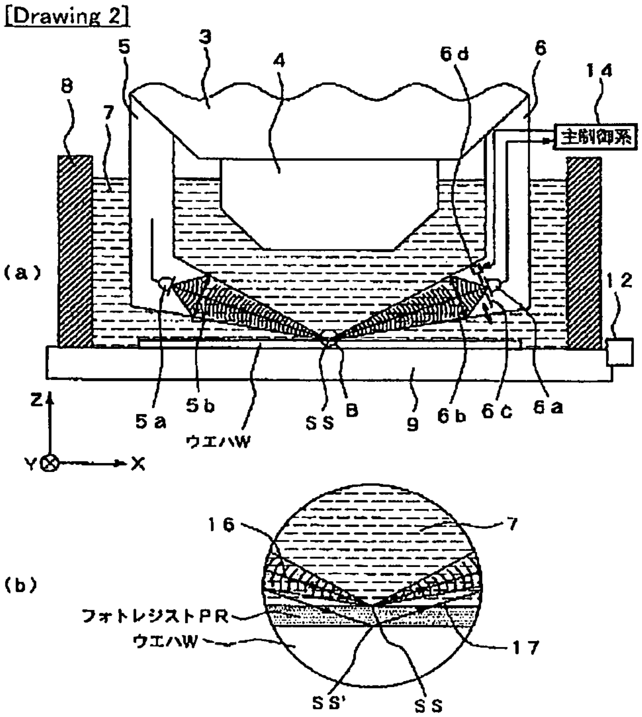
DRAWINGS

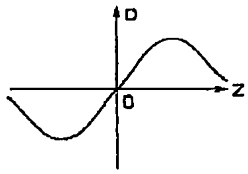
[Drawing 1]



[Drawing 2]



[Drawing 3]



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